Large-scale, high-resolution wind resource mapping for strategic environmental assessment and wind farm planning and development

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Large-scale, high-resolution wind resource mapping for **strategic environmental assessment** and **wind farm planning and development**

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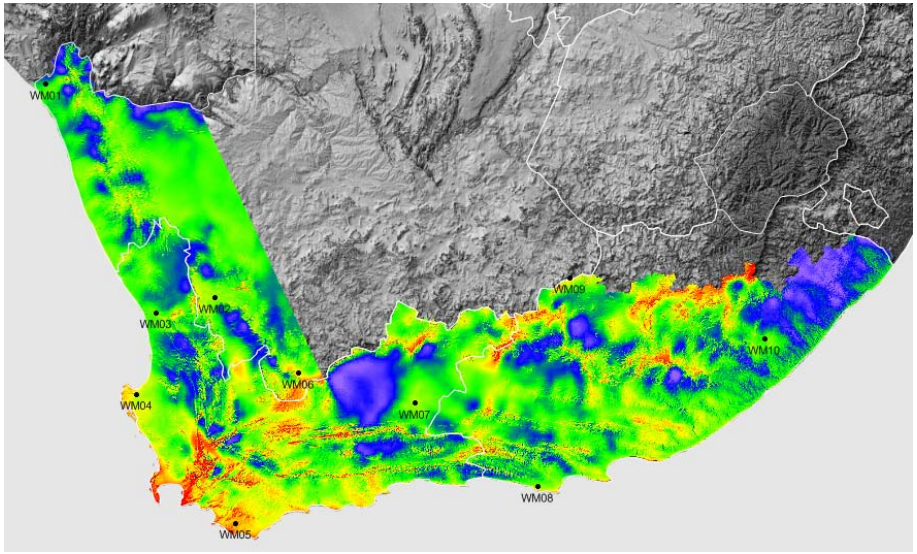
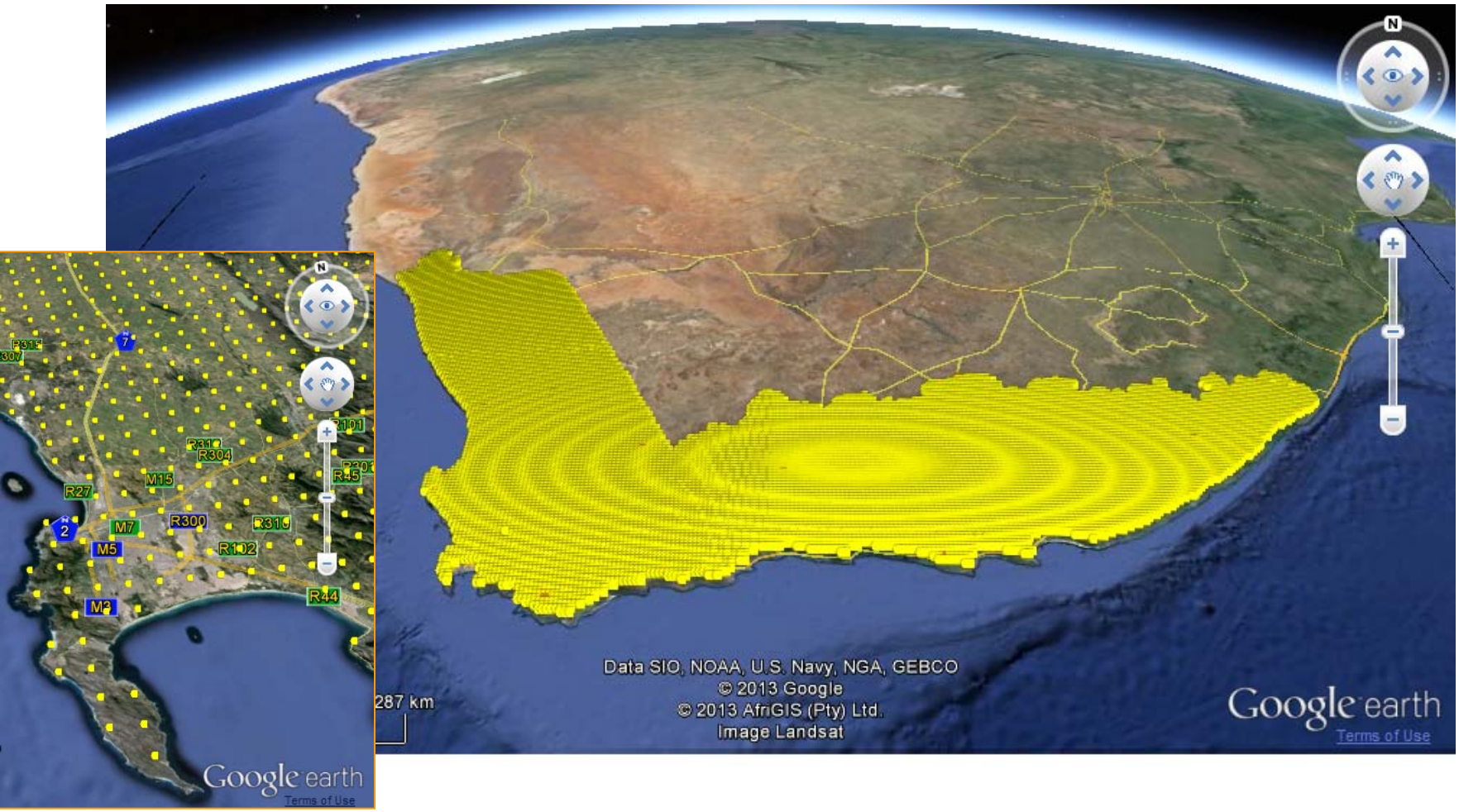


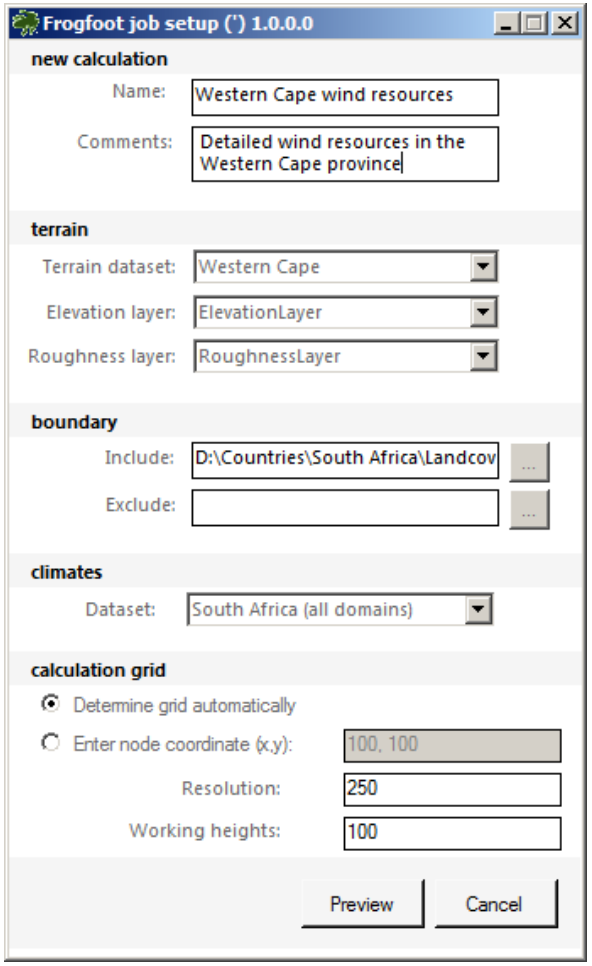
Windaba 2013
Cape Town, South Africa

First Verified Numerical Wind Atlas 2012



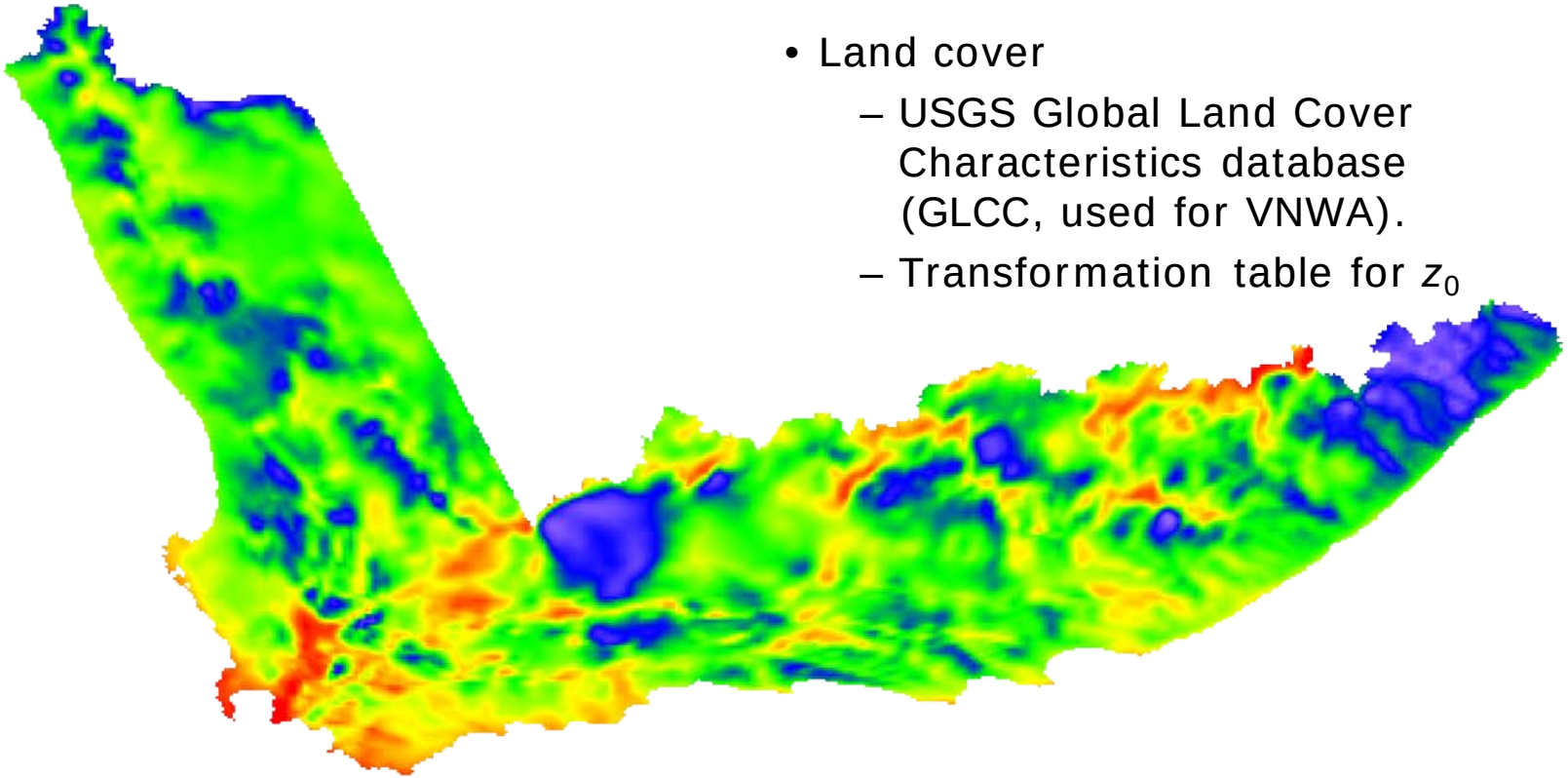
New wind resource mapping methodology

- *Frogfoot* implementation of WAsP
  - Database of wind climates
  - Database of elevation maps
  - Database of roughness maps
- Principle of operation
  - Batch mode operation
  - Distributed computing
  - Wind atlas interpolation to every prediction site.
  - Results in MySQL database
  - Export to GIS formats
- WAsP standard modelling
  - Industry-standard model
  - Linearised flow model
  - Default parameters



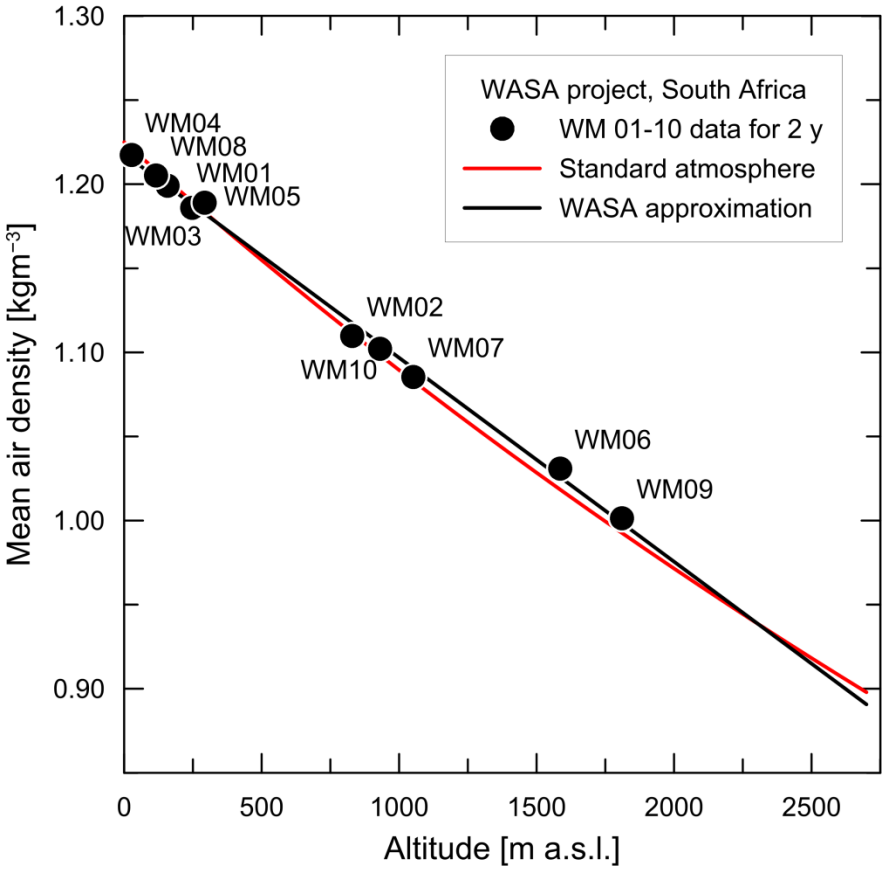
Available input data for modelling

- First Verified Numerical Wind Atlas
  - KAMM mesoscale model
  - Virtual mast for every 5 km
- Elevation
  - 20-m height contours from 1:50,000 South African topographical maps.
- Land cover
  - USGS Global Land Cover Characteristics database (GLCC, used for VNWA).
  - Transformation table for z_0

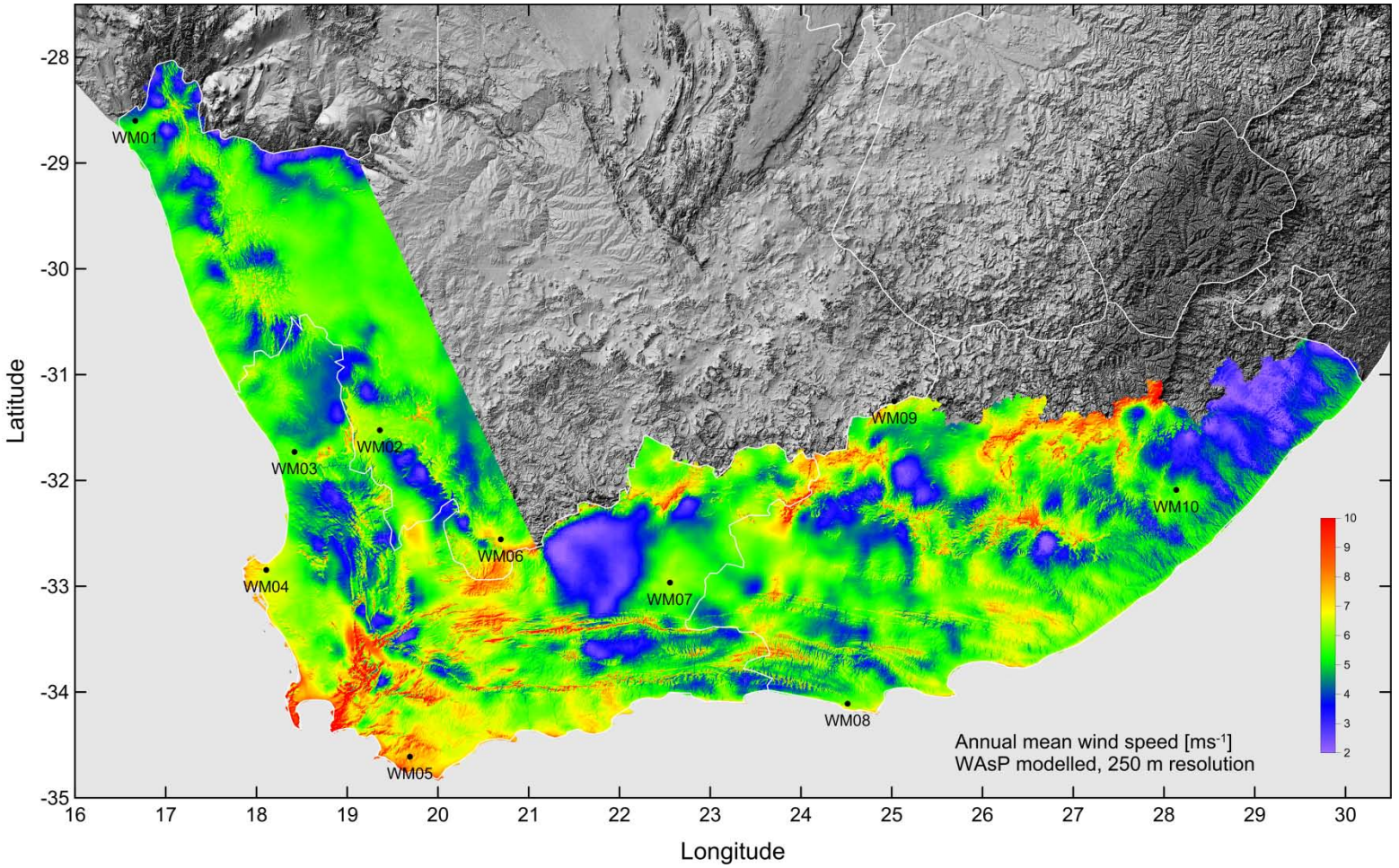


Output data in public domain

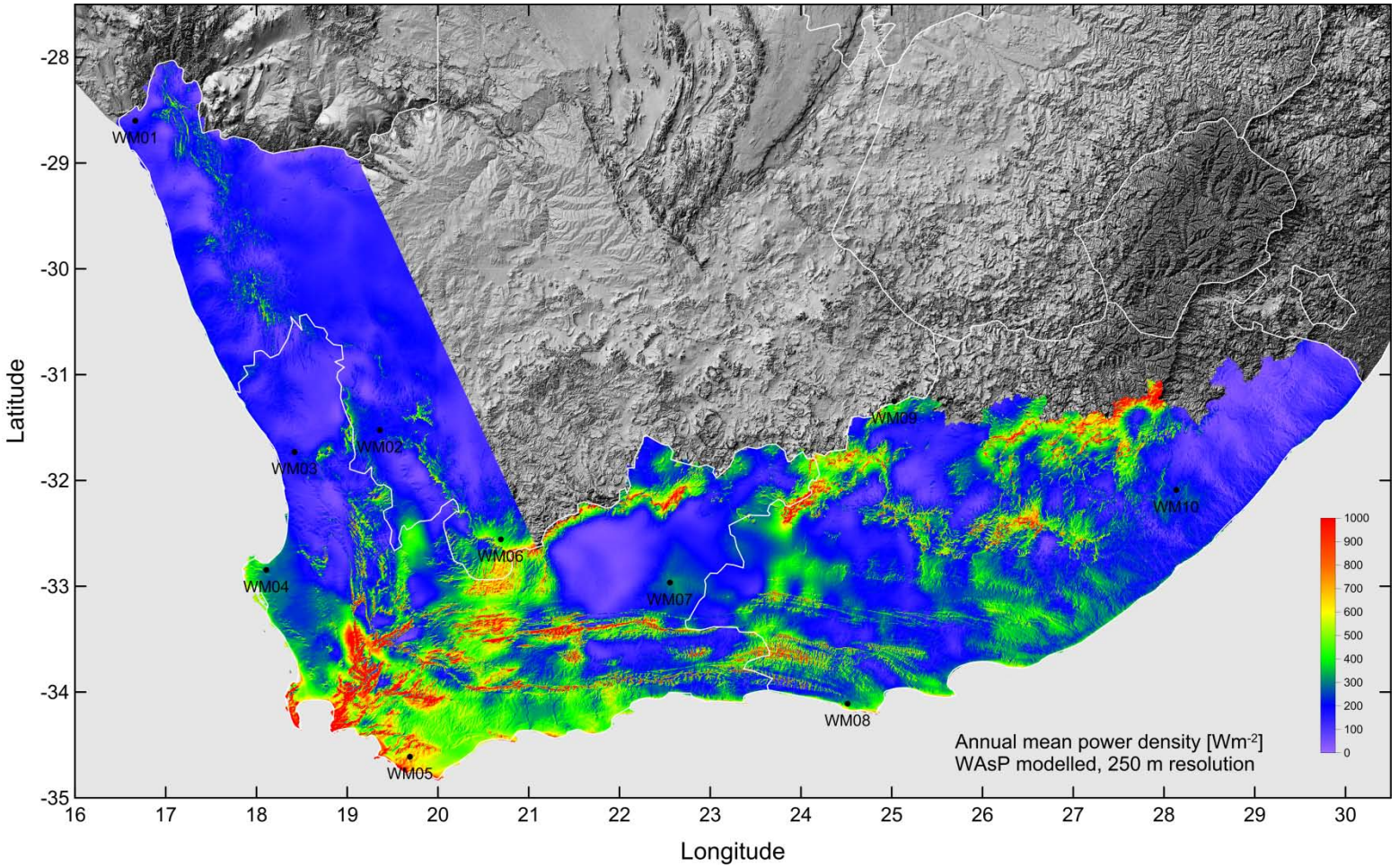
- Common characteristics
  - 250 × 250 m grid results
  - Modelling resolution ~1 m
  - 100 m above ground level
  - ArcGIS ASC output format
- Mean wind speed *U*
  - 10 min average in [ms^{-1}]
- Mean power density *P*
  - 10 min average in [Wm^{-2}]
  - Site-specific air density
- Elevation *z*
  - Meters above sea level [m]
- Ruggedness index RIX
  - WAsP standard parameters



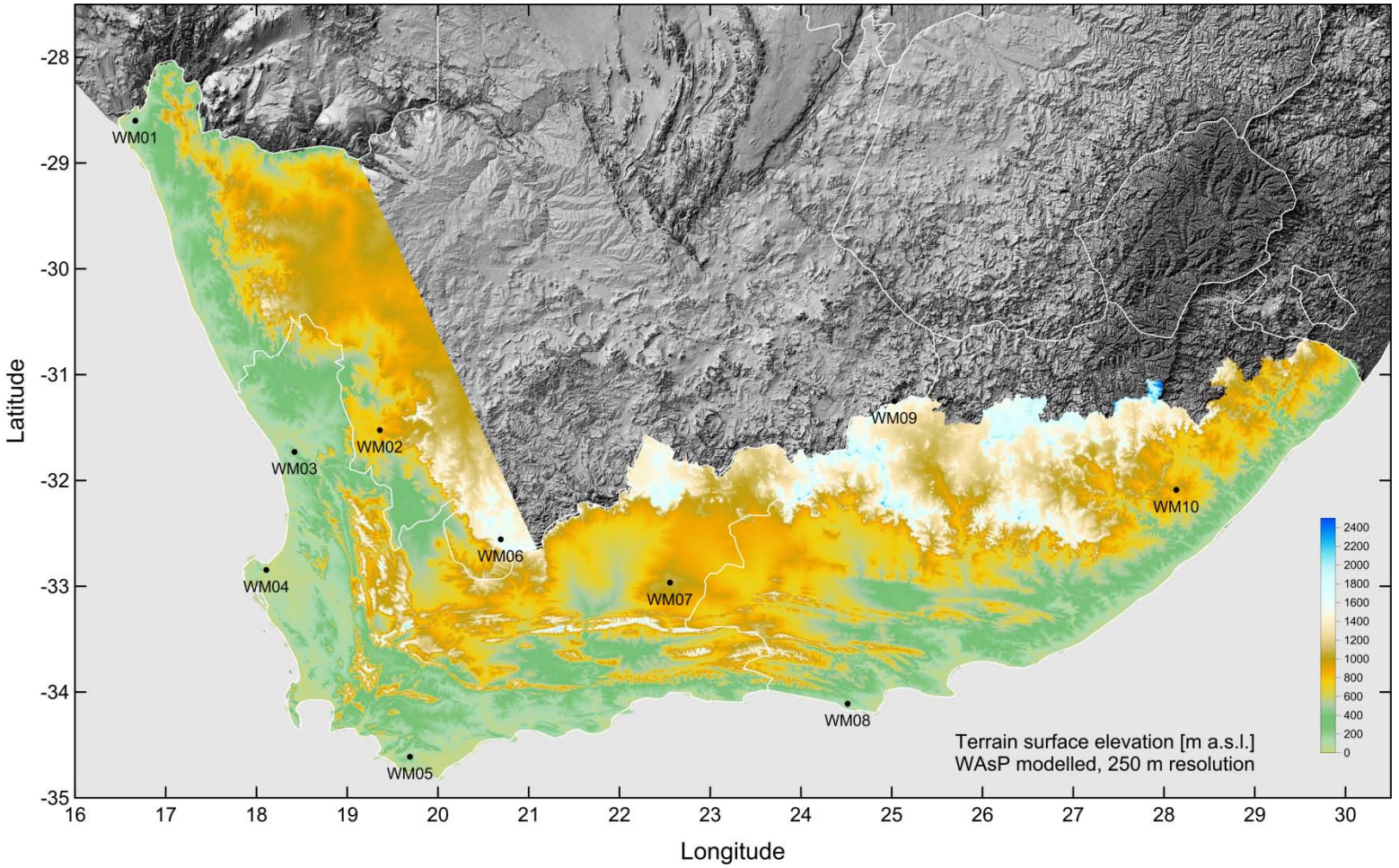
WASA wind resource @ 100 m – wind speed



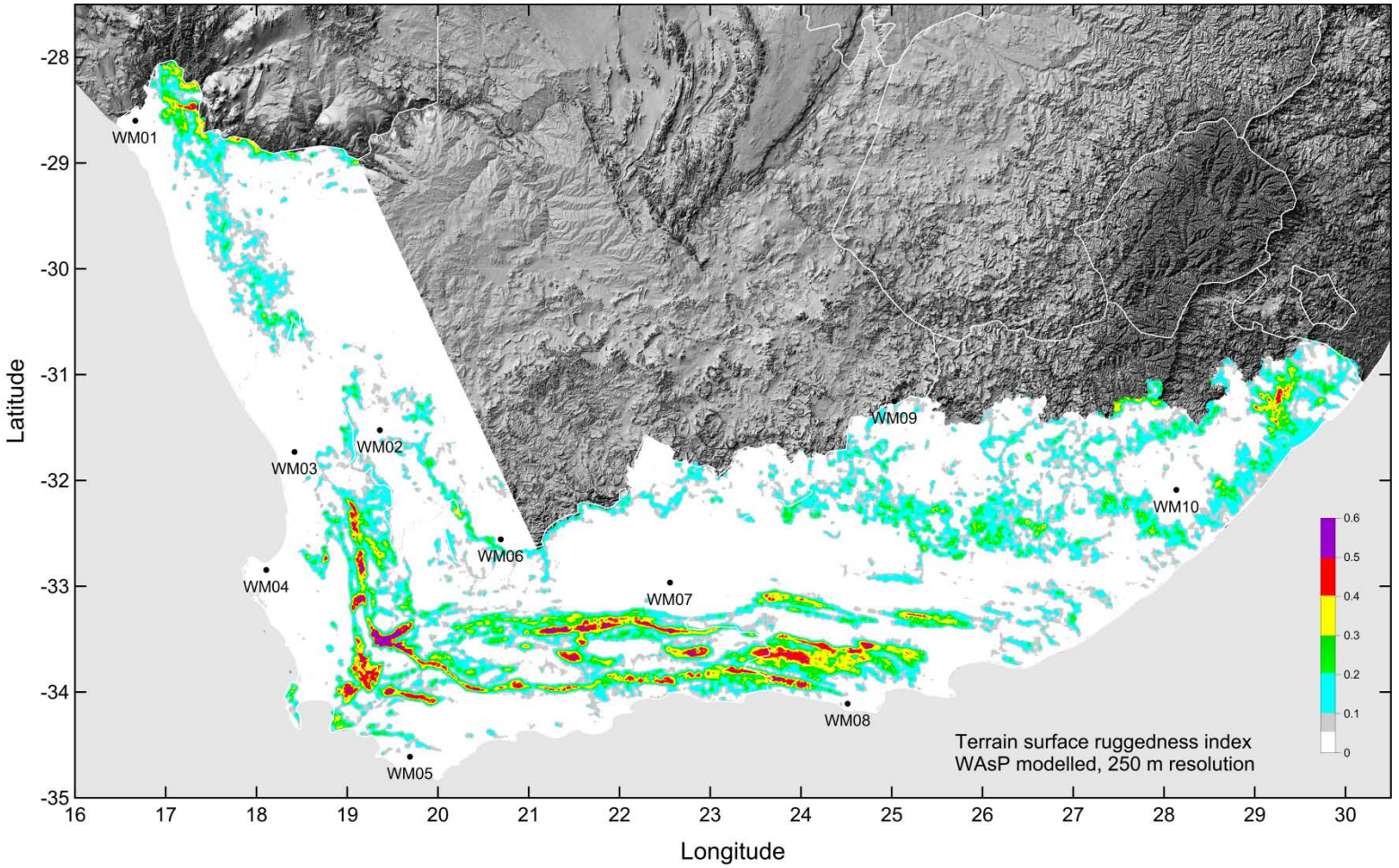
WASA wind resource @ 100 m – power density



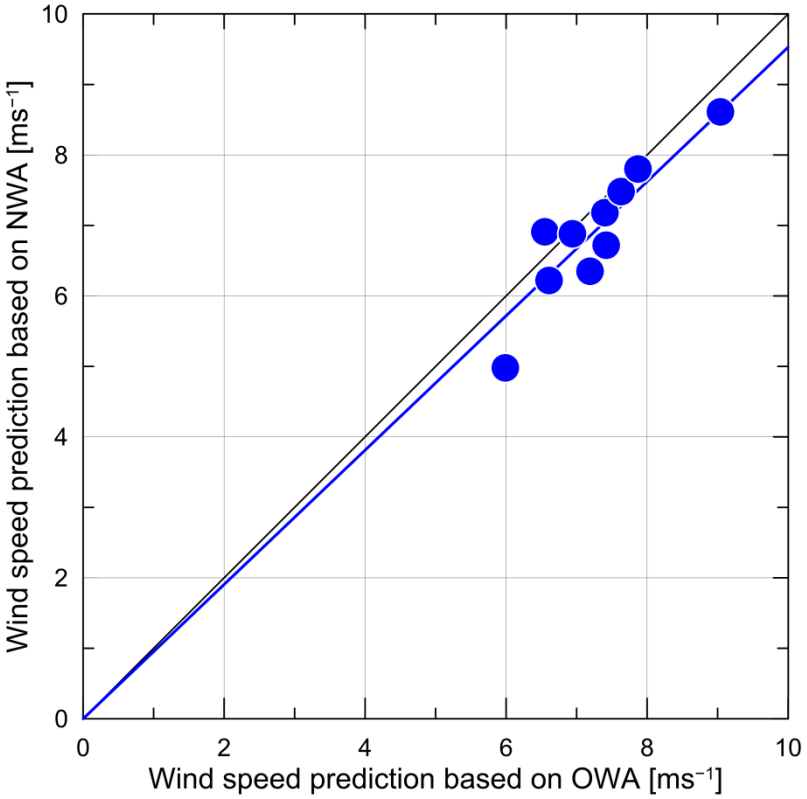
WASA domain terrain elevation

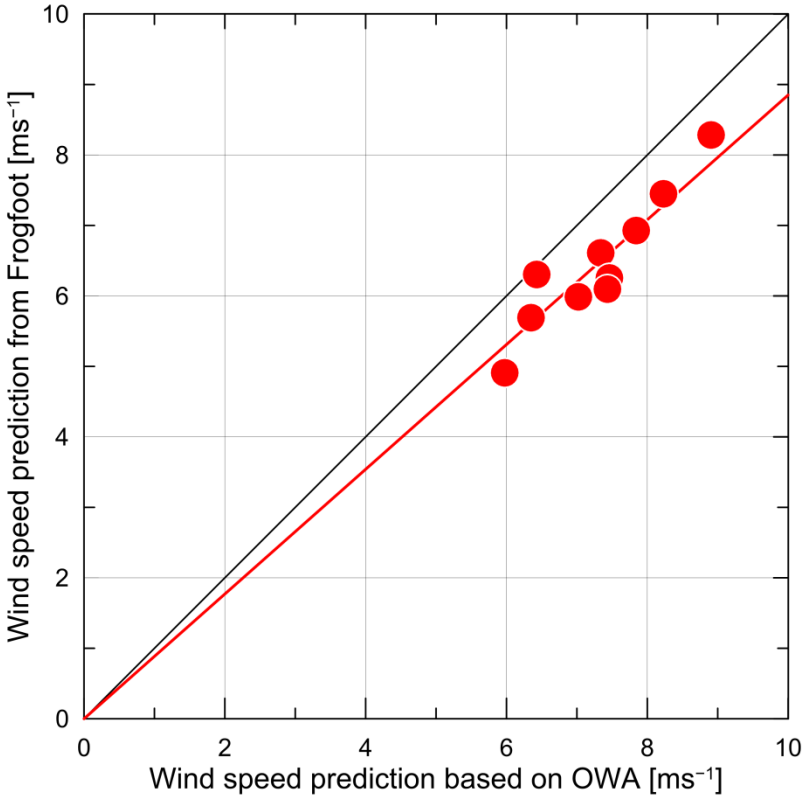


WASA domain terrain ruggedness index



Verification against wind measurements @ 10 masts



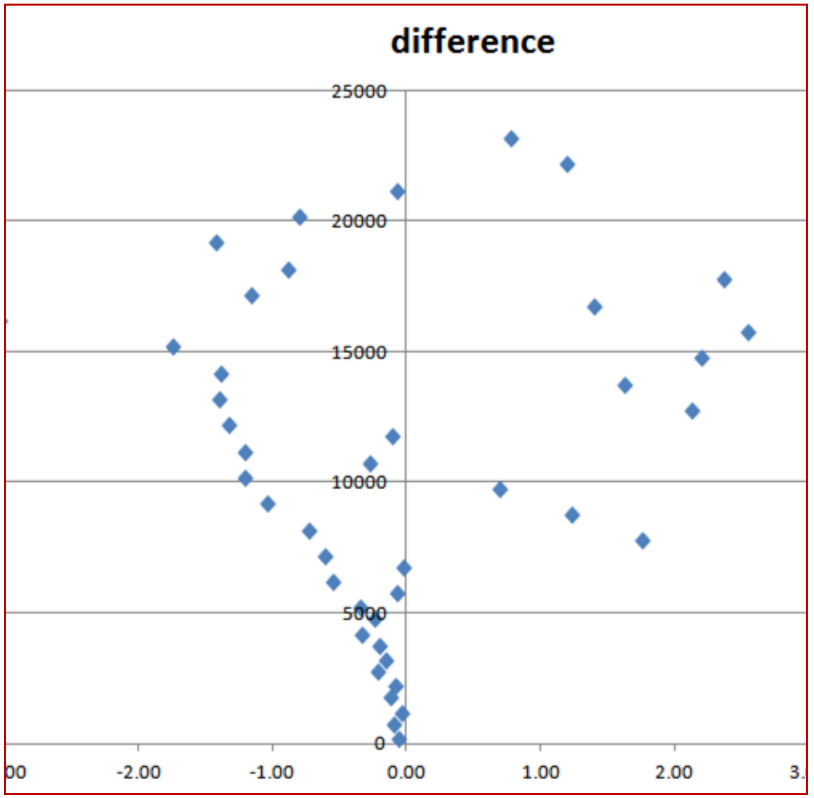


- First Verified Numerical Wind Atlas compared to observed winds (2y).
- *Testing wind-climatological inputs*

- Frogfoot large-scale calculations compared to observed winds (2y).
- *Testing wind + topographical inputs*

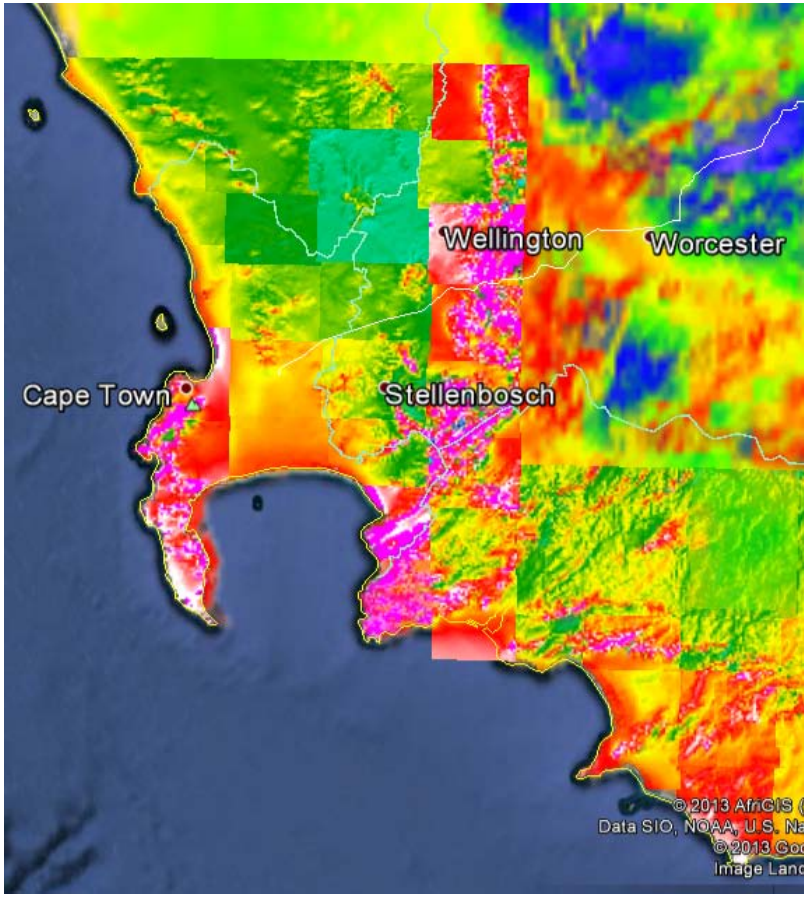
Further quality assurance

- Manual vs. automated approach
  - Comparison of software tools
  - Coordinate systems check
  - Coastlines and masks check
  - Elevation data check
  - Visual inspection of tiles of wind resource estimates.
  - Difference between resource estimates at similar points.
- Final data sets
  - Unedited and not limited
  - Extreme power density values
  - Includes blank nodes too
  - Editing sometimes necessary



Detailed wind resource mapping

- 250-m Frogfoot results
  - Standardised set-up
- User-generated maps
  - any scale and resolution
- Recommendations
  - Tile size – keep small
  - Site-specific parameters
  - Detailed elevation maps
  - Detailed roughness maps



Metadata documents for wind resource data sets

- Metadata for data sets
  - Data set specifications
  - Data provider
  - Contact information
- Data set parameters
- Coordinate system
- Technology (models & data)
- Detailed notes
  - Purpose
  - Methodology
  - Limitations
  - Available documentation
  - Acknowledgements
  - Disclaimer
  - Four maps of *U*, *P*, *z* and RIX

- Limitations
  - Operational envelope of WAsP
  - Verified numerical wind atlas (KAMM mesoscale model)
  - Input topographical data
  - Complex terrain (RIX > 5%)
  - Built-up areas
  - Forested areas

The wind resource maps are subject to change without notice if and when more accurate and reliable data, models and procedures become available.

Wind farm planning and development

- Identification and ranking of potential wind farm sites.
- Initial analyses and design
- Project planning
- Pre-feasibility studies
  - Resource assessment
  - Some site assessment
- Design of measurement campaign
  - Number of masts
  - Siting of masts
  - Orientation of sensor booms
  - Mounting of lightning rod and navigation lights.

Summary and conclusions

- Wind resources in WASA domain
  - Large-scale: ~346,500 km^2
  - High-resolution: 250-m grids
  - Results in public domain: wasadata.csir.co.za/wasa1
- Data sets specifically developed for
  - Planning and Strategic Environmental Assessment
  - WF planning and development
- Comprehensive verification and QA
  - Software development phase
  - Manual checks in several areas
- Wind resources pt underestimated
  - VNWA on average 5% too low
  - Topo-data means another ~5%
- Wind resource maps preliminary
  - Strategic environmental assessments in 2013
- Updated WASA results April 2014
  - Updated mesoscale results
  - More detailed elevation maps
  - Updated land cover maps
  - Adjusted roughness lengths
  - Verification for 3y @ 10 masts
- Updated wind resource maps too!
  - U, P, z and RIX as shown today
  - Land cover and roughness (z_0)
  - Best practice and guidelines
- All WASA results will be presented at public workshops in April 2014.

Acknowledgements

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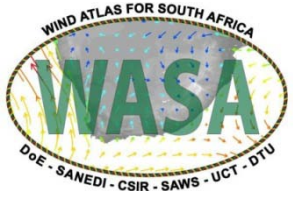
- UNDP-GEF through South African Wind Energy Programme (SAWEP)
- Royal Danish Embassy

WASA Project Steering Committee:

DoE (chair), DEA, DST, UNDP, Danish Embassy, SANEDI



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